

CLAIMS

What is claimed is:

1. A modem pool system capable of mitigating alien crosstalk, the system comprising:

5 a first modem pool comprising at least two modems;

at least one protected line connected to one of said modems;

at least one sensor line connected to another of said modems;

at least one alien crosstalk predictor operative to sample an alien signal on said
at least one sensor line and provide an alien crosstalk prediction signal; and

10 at least one alien crosstalk prediction summation element operative to receive
said alien crosstalk prediction signal from said alien crosstalk predictor and subtract said
alien crosstalk prediction signal from a data transmission signal on said protected line.

15 2. A system according to claim 1 wherein said predictor is operative to sample a
plurality of said sensor lines and provide said alien crosstalk prediction signal to a different
one of said summation elements at each of said modems connected to said protected lines.

20 3. A system according to claim 1 wherein said modem pool is configured to
transmit data via said protected line.

4. A system according to claim 1 wherein said modem pool is configured to
refrain from transmitting data via said sensor line.

25 5. A system according to claim 1 wherein each of said lines are assembled within
a binder including at least one alien line not connected to said modem pool.

6. A system according to claim 1 wherein any of said modems in said modem
pool comprises:

30 a crosstalk cancellation (CTC) filter operative to receive a signal from any of

said modems and provide a crosstalk cancellation signal; and

a crosstalk cancellation summation element operative to receive said crosstalk
cancellation signal from said CTC and subtract said crosstalk cancellation signal from any
of said lines.

7. A system according to claim 6 wherein any of said modems in said modem pool comprises:

5 an analog front end (AFE); and

a digital signal processor (DSP) in communication with said AFE.

8. A system according to claim 7 wherein said alien crosstalk prediction summation element is intermediate said AFE and said DSP at a terminus of said protected line.

10 9. A system according to claim 7 wherein said crosstalk cancellation summation element is operative to subtract said crosstalk cancellation signal at a point intermediate said AFE and said DSP.

15 10. A system according to claim 7 wherein said alien crosstalk predictor is operative to sample an alien signal on said sensor line at a point intermediate said AFE and said DSP.

20 11. A system according to claim 10 wherein said crosstalk cancellation summation element is operative to subtract said crosstalk cancellation signal at a point intermediate said AFE and said alien crosstalk predictor sample point.

25 12. A system according to claim 7 wherein said crosstalk cancellation summation element is operative to subtract said crosstalk cancellation signal at a point intermediate said AFE and said alien crosstalk prediction summation element.

30 13. A system according to claim 7 and further comprising a variable delay unit intermediate said crosstalk cancellation summation element and said alien crosstalk prediction summation element.

14. A system according to claim 7 wherein the sampling rates at the input and output of said CTC and said alien crosstalk predictor are identical.

15. A system according to claim 1 and further comprising a second modem pool comprising at least one modem, wherein said protected line and said sensor line connect said modem pools.

5 16. A system according to claim 1 wherein said alien crosstalk predictor is an adaptive LMS filter.

10 17. A system according to claim 7 wherein said CTC filter is an adaptive LMS filter.

18. In a modem pool system capable of mitigating alien crosstalk, the system including a first modem pool having at least one modem and a plurality of lines connected to the modem pool, at least one alien crosstalk predictor operative to sample an alien signal on any of the lines and provide an alien crosstalk prediction signal, and an alien crosstalk prediction summation element operative to receive the alien crosstalk prediction signal from the alien crosstalk predictor and subtract the alien crosstalk prediction signal from a data transmission signal on any of the lines, a method of selecting sensor lines comprising:

- a) initializing said system;
- b) determining an achievable transmission rate for each of said lines;
- c) operating said system in a receive-only mode;
- d) selecting a subset of said lines as candidate sensor lines, wherein said lines excluded from said subset are candidate protected lines;
- e) operating said alien crosstalk predictor in conjunction with said candidate sensor lines;
- f) calculating a transmission capacity gain for said candidate protected lines;
- g) calculating a transmission capacity loss for said candidate sensor lines;
- h) calculating a net transmission capacity gain for said system as the difference between said transmission capacity gain and said transmission capacity loss;
- i) repeating steps d) - h) for a plurality of subsets of candidate sensor lines; and
- j) designating as sensor lines one of said plurality of subsets of candidate sensor lines which yields the greatest net transmission capacity gain for said system.

19. A method according to claim 18 wherein said calculating step f) comprises estimating noise reduction on each of said candidate protected lines.

5 20. A method according to claim 18 wherein said calculating step g) comprises calculating said transmission capacity loss as the capacity of said candidate sensor lines were data transmitted via said candidate sensor lines.

21. A modem pool system capable of mitigating alien crosstalk, the system comprising:

10 a first modem pool comprising a plurality of modems;

a second modem pool comprising a plurality of modems;

15 at least one protected line connecting said modem pools;

at least one sensor line connecting said modem pools;

20 a precoder operative to sample a transmission signal on said sensor line at said first modem pool and provide a precoding signal;

a precoding summation element operative to receive said precoding signal from said precoder and add said precoding signal to a data transmission signal on said protected line at said first modem pool prior to said first modem pool transmitting said precoded-and-data transmission signal on said protected line;

25 an alien crosstalk predictor operative to sample a received signal on said sensor line at said second modem pool and provide an alien crosstalk prediction signal; and

an alien crosstalk prediction summation element operative to receive said alien crosstalk prediction signal from said alien crosstalk predictor and subtract said alien crosstalk prediction signal from said received signal on said protected line at said second modem pool.

22. A system according to claim 21 wherein said precoder comprises:

30 an alien crosstalk predictor copy operative to sample said transmission signal on said sensor line at said first modem pool and provide a facsimile alien crosstalk precoding signal;

a channel compensation filter operative to receive said facsimile alien crosstalk precoding signal from said alien crosstalk predictor copy and provide said precoding signal.

5 23. A system according to claim 21 wherein said modem pools are configured to transmit data via said protected line.

24. A system according to claim 21 wherein said modem pools are configured to transmit data via said sensor line.

10 25. A system according to claim 21 wherein each of said lines are assembled within a binder including at least one alien line not connected to either of said modem pools.

15 26. A system according to claim 23 wherein said alien crosstalk predictor is operative to provide control information to said alien crosstalk predictor copy, and wherein said alien crosstalk predictor copy is operative to duplicate the operation of said alien crosstalk predictor using said control information.

20 27. A system according to claim 23 wherein said channel compensation filter is equal to the transfer function ratio of said sensor line to said protected line.

28. A system according to claim 21 wherein any of said modems in said modem pools comprises:

25 a crosstalk cancellation (CTC) filter operative to receive a signal from any of said modems; and

a crosstalk cancellation summation element operative to receive a crosstalk cancellation signal from said CTC and subtract said crosstalk cancellation signal from any of said lines.

30 29. A system according to claim 28 wherein any of said modems in said modem pools comprises:

an analog front end (AFE); and

a digital signal processor (DSP) in communication with said AFE.

30. A system according to claim 29 wherein said alien crosstalk prediction summation element is intermediate said AFE and said DSP at a first terminus of said protected line, and wherein said precoding summation element is intermediate said AFE and said DSP at a second terminus of said protected line.

31. A system according to claim 29 wherein said crosstalk cancellation summation element is operative to subtract said crosstalk cancellation signal at a point intermediate said AFE and said DSP.

32. A system according to claim 29 wherein either of said alien crosstalk predictor and said precoder is operative to sample a signal on said sensor line at a point intermediate said AFE and said DSP.

33. A system according to claim 32 wherein said crosstalk cancellation summation element is operative to subtract said crosstalk cancellation signal at a point intermediate said AFE and said sensor line sample point.

34. A system according to claim 29 wherein said crosstalk cancellation summation element is operative to subtract said crosstalk cancellation signal at a point intermediate said AFE and said alien crosstalk prediction summation element.

35. A system according to claim 29 and further comprising a variable delay unit intermediate said crosstalk cancellation summation element and said alien crosstalk prediction summation element.

36. A system according to claim 29 wherein the sampling rates at the input and output of said CTC and either of said alien crosstalk predictor and said precoder are identical.

37. A system according to claim 21 wherein either of said alien crosstalk predictor and said precoder is an adaptive LMS filter.

38. A system according to claim 29 wherein said CTC filter is an adaptive LMS filter.

5 39. A system according to claim 21 wherein one of said modems in said first modem pool terminates said sensor line and comprises:

a sensor line modem analog front end (AFE); and

a sensor line modem digital signal processor (DSP) in communication with said sensor line modem AFE and comprising:

10 a mapper unit; and

15 a transmit signal processing unit operative to receive output from said mapper unit.

20 40. A system according to claim 39 wherein said precoder is operative to sample said transmission signal intermediate said mapper unit and said transmit signal processing unit.

25 41. A system according to claim 40 wherein one of said modems in said first modem pool terminates said protected line and comprises:

a protected line modem analog front end (AFE); and

a protected line modem digital signal processor (DSP) in communication with said AFE and comprising:

30 42. a mapper unit operative to provide said data transmission signal to said precoding summation element; and

42. a modulo unit operative to receive said precoded-and-data transmission signal from said precoding summation element and provide a modulo reduced precoded-and-data transmission signal prior to said first modem pool transmitting said precoded-and-data transmission signal on said protected line.

30 42. A system according to claim 41 wherein said precoding summation element is intermediate said mapper unit and said modulo unit.

43. A system according to claim 41 wherein said protected line modem DSP comprises an intersymbol interference cancellation filter operative to receive output from said modulo unit and provide output to said precoding summation element for signal subtraction thereat.

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44. A system according to claim 43 wherein said protected line modem DSP comprises a transmit signal processing unit operative to receive output from said modulo unit.

10 45. A system according to claim 21 wherein one of said modems in said second
11 modem pool terminates said sensor line and comprises:

a sensor line modem analog front end (AFE); and

a sensor line modem digital signal processor (DSP) in communication with said sensor line modem AFE and comprising:

an equalizing unit; and

a decision unit operative to receive output from said equalizing unit.

46. A system according to claim 45 wherein said alien crosstalk predictor is operative to sample said received signal intermediate said equalizing unit and said decision unit.

47. A system according to claim 46 wherein one of said modems in said second modem pool terminates said protected line and comprises:

a protected line modem analog front end (AFE); and

a protected line modem digital signal processor (DSP) in communication with said protected line modem AFE and comprising:

an equalizing unit operative to provide output to said alien crosstalk prediction summation element;

a modulo unit operative to receive output from said alien crosstalk

30 prediction summation element; and

a decision unit operative to receive output from said modulo unit,

and wherein said alien crosstalk prediction summation element is intermediate said equalizing unit and said modulo unit.

48. A method for mitigating alien crosstalk in a modem pool environment, the method comprising:

5 sampling an alien signal on at least one sensor line connected to at least one modem in a modem pool;

filtering said sampled signal, thereby providing an alien crosstalk prediction signal; and

subtracting said alien crosstalk prediction signal from a data transmission signal received on at least one protected line connected to at least one other modem in said 10 modem pool.

49. A method according to claim 48 and further comprising transmitting data via said protected line.

50. A method according to claim 48 and further comprising refraining from transmitting data via said sensor line.

51. A method according to claim 48 and further comprising:

sampling at least one signal at at least one of said modems;

deriving a crosstalk cancellation signal for said signal; and

subtracting said crosstalk cancellation signal from any of said lines.

52. A method according to claim 48 wherein said subtracting step comprises subtracting intermediate an AFE and a DSP of any of said modems at a terminus of said 25 protected line.

53. A method according to claim 51 wherein said subtracting said crosstalk cancellation signal comprises subtracting said crosstalk cancellation signal at a point intermediate an AFE and a DSP of any of said modems.

30 54. A method according to claim 48 wherein said sampling step comprises sampling said alien signal at a point intermediate an AFE and a DSP of any of said modems at a terminus of said sensor line.

55. A method according to claim 51 wherein said sampling steps comprise sampling at identical rates.

5 56. A method for mitigating alien crosstalk in a modem pool environment, the method comprising:

sampling at a first modem pool a transmission signal on at least one sensor line connecting at least one sensor line modem in said first modem pool to at least one other sensor line modem in a second modem pool;

10 generating a precoding signal from said sampled transmission signal;

adding said precoding signal to a data transmission signal on at least one protected line connecting at least one protected line modem in said first modem pool to at least one protected line modem in said second modem pool, wherein said adding step comprises adding at said first modem pool prior to said first modem pool transmitting said precoded-and-data transmission signal on said protected line to said second modem pool;

15 sampling at said second modem pool a received signal on said sensor line;

generating an alien crosstalk prediction signal from said sampled received signal; and

20 subtracting said alien crosstalk prediction signal from said received signal on said protected line at said second modem pool.

57. A method according to claim 56 wherein said generating a precoding step comprises:

25 generating a facsimile alien crosstalk precoding signal from said sampled transmission signal; and

performing channel compensation on said facsimile alien crosstalk precoding signal, thereby providing said precoding signal.

58. A method according to claim 56 wherein said generating a precoding step comprises:

30 performing channel compensation on said sampled transmission signal; and

generating a facsimile alien crosstalk precoding signal from said channel-compensated sampled transmission signal, thereby providing said precoding signal.

5 59. A method according to claim 56 and further comprising transmitting data via said protected line.

60. A method according to claim 56 and further comprising transmitting data via said sensor line.

10 61. A method according to claim 59 and further comprising said second modem pool providing control information to said first modem pool, and wherein said generating a precoding signal step comprises duplicating the operation of said generating an alien crosstalk prediction signal step using said control information.

15 62. A method according to claim 57 wherein said performing channel compensation step comprises performing using the transfer function ratio of said sensor line to said protected line.

20 63. A method according to claim 58 wherein said performing channel compensation step comprises performing using the transfer function ratio of said sensor line to said protected line.

25 64. A method according to claim 56 and further comprising:
sampling at least one signal at at least one of said modems;
deriving a crosstalk cancellation signal for said signal; and
subtracting said crosstalk cancellation signal from any of said lines.

65. A method according to claim 64 wherein said sampling steps comprise
30 sampling at identical rates.

66. A method according to claim 56 and further comprising mapping a data stream within a sensor line modem digital signal processor (DSP), and wherein said sampling a

transmission signal step comprises sampling said mapped data stream prior to its transmission.

67. A method according to claim 56 and further comprising:

5 mapping a data stream within a sensor line modem digital signal processor (DSP), thereby providing said data transmission signal.

68. A method according to claim 56 and further comprising:

10 modulo reducing said precoded-and-data transmission signal prior to said first modem pool transmitting said precoded-and-data transmission signal on said protected line.

15 69. A method according to claim 68 and further comprising:

canceling intersymbol interference from said modulo reduced precoded-and-data transmission signal.

20 70. A method according to claim 69 wherein said protected line modem DSP comprises a transmit signal processing unit operative to receive output from said modulo unit.

71. A method according to claim 56 wherein said sampling a received signal step comprises sampling said received signal intermediate an equalizing unit and a decision unit in a sensor line modem digital signal processor (DSP).

25 72. A method according to claim 56 wherein said subtracting step comprises subtracting intermediate an equalizing unit and a modulo unit in a protected line modem digital signal processor (DSP).